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Contingent Responsivity in E-Books Modeled From Quality Adult-Child Interactions: Effects on Children's Learning and Attention

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Experiences of contingent responsivity during shared book reading predict better learning outcomes. However, it is unclear whether contingent responsivity from a digital book could provide similar support for children. The effects on story recall and engagement interacting with a digital book that responded contingently on children's vocalizations (contingent book) were investigated, with a focus on the role of individual differences in attention. The study used a within-subject design with 3 experiments from 90 3- to 5-year-old children. Children were presented with a contingent book and 3 noncontingent control conditions: a board book (Experiment 1), a static digital book (Experiment 2), and an animated book (Experiment 3). The use of the contingent book significantly increased children's story recall and was found to be especially useful for children with less developed attention regulation.

Keywords: attention, individual differences, educational technology, preschool-age children, contingent interactions

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A critical feature of effective communication between an adult and a child is the presence of contingent responsivity; that is, that the feedback that the child receives is dependent upon their behavior (Bornstein, Tamis-LeMonda, Hahn, & Haynes, 2008). In the context of spoken language, a contingent response is when an adult responds reliably, promptly, and accurately to a child's vocalizations (Roseberry, Hirsh-Pasek, & Golinkoff, 2014). Contingent responsivity enables children to feel in control, maintains their focus, permits self-pacing, and encourages children to continue the interaction when each of their vocalizations is met with an appropriate response (Hirsh-Pasek et al., 2015). This interaction contrasts with adult-directed interactions of one-sided control in which the parent leads and the child passively complies or resists and disengages. Contingent caregiver responsivity extends children's capacities and is positively associated with emerging cognitive and language competence (Tamis-LeMonda, Bornstein, & Baumwell, 2001).

Shared book reading is a common activity that promotes contingent responsivity. Experiences of contingent responsivity during shared book reading predict better reading and language outcomes (Dickinson, Griffith, Golinkoff, & Hirsh-Pasek, 2012). The role of contingency is especially important during shared book reading because children are given the opportunity for conversational turns that lay the groundwork for literacy skills. Adults facilitate children's learning during shared book reading when they add more information, ask follow-up questions, praise, or point to relevant story content such as pictures that match the pronounced words (Hargrave & Sénéchal, 2000). Adults' contingent responsivity through pauses and prompts direct children's attention to relevant story content that engage and help children interpret and

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understand the story narrative (Strouse, O'Doherty, & Troseth, 2013). When children vocalize and attempt to read along, adults facilitate children's understanding of the story with reinforced responsiveness by pointing to relevant story content such as pictures that match the pronounced words (Flack, Field, & Horst, 2018). These nonverbal cues or gestures can serve as forms of contingent support, such as adults pointing instead of using verbal cues. Contingent responsivity encourages the child's communicative efforts and facilitates children's ability to learn features, such as congruent pictures associated with the pronounced words, and enables them to later reproduce an understanding about the words in relation to the story (Bus, 2001).

Prior studies have found that children learn significantly more when adults ask children to repeat target words from the text through questions and comments (Blewitt, Rump, Shealy, & Cook, 2009; Sénéchal, 1997). Echo reading—a common pedagogical practice at school and at home—is a shared reading book strategy that occurs when children repeat a phrase or sentence immediately after it is read to them (Stahl & Heubach, 2005). The repeated reading component is intended to provide practice so that children develop fluent and automatic reading (Jennings, Caldwell, & Lerner, 2013). However, it is unknown whether children receiving a nonverbal contingent response upon repeating the text in an echo reading paradigm would have similar benefits as when adults contingently respond to children through questions and comments.

Children's earliest experiences with books are no longer limited to paper, and books are now accessible in the form of electronic books (e-books) through computers, smartphones, and tablets (Rideout, 2017). Many e-books have interactive features such as embedded animations, games, and sound effects that are activated by touching a spot on the screen (i.e., hotspots; Piotrowski & Krcmar, 2017). However, these kinds of interactive features have often been found to negatively affect learning in young children, in stark contrast to the contingent responsivity provided by adult coreaders (Bus, Takacs, & Kegel, 2015; Parish-Morris, Mahajan, Hirsh-Pasek, Golinkoff, & Collins, 2013). While the contingent responsivity adults provide synchronizes with children's story-related vocalizations, interactive features common in digital books—puzzles, games, hotspots, erroneous visuals and sound effects—may draw children's attention away from the story-related elements relevant to the narrative (de Jong & Bus, 2002).

There is evidence that specific types of contingent interactions using e-books promote different emergent literacy skills. Children's word reading and phonological awareness improved when the e-book interaction included adult responses that focused children's attention on the sounds of words in the story compared to reading printed books with contingent adult responses, reading e-books alone, or receiving the regular kindergarten program (Segal-Drori, Korat, Shamir, & Klein, 2010). Children's expressive vocabulary was enhanced when an e-book posed extratextual vocabulary questions compared to e-books with hotspots, e-books without questions, or independently reading the e-book (Smeets & Bus, 2012). Tactile contingency such as requiring children to touch a relevant image improved 2- to 3-year-old children's word learning compared to touching anywhere on the screen or passive interaction with the screen (Kirkorian, Choi, & Pempek, 2016). Conversely, it has been reported that children with low self-control are prone to excessive tapping of touchscreens, which may lead to more arbitrary tapping, frustration, and less learning (Troseth, Russo, & Strouse, 2016). One of the goals of this study was to design a paradigm in which an e-book responds contingently to children's vocalizations, reducing the need for tactile responsivity from children.

Other studies show that when comparing language exposure through contingent interactions with a person, children demonstrate quantifiably smaller amounts of learning from exposure to the same material presented noncontingently through digital media (Dore et al., 2018; Roseberry et al., 2014). Research on children's verbal behaviors during shared book reading have found that children's repetition of parents' vocalizations is uniquely and positively related to children's overall story retelling abilities (Kang, Kim, & Pan, 2009); yet little is known about whether children receiving a contingent response from an e-book upon repeating the text would have similar benefits on children's story recall. There is evidence that contingent responsivity in adult-child interactions produces large gains in learning outcomes and contingent responsivity in e-book interactions can improve vocabulary knowledge and phonemic awareness in young children. It is unknown whether contingent responsivity in a digital book could provide similar support for children's ability to recall, retell, and describe key story events.

The current experiments examined whether a digital book that responds contingently to child vocalizations (contingent book) would increase story recall and engagement compared to three noncontingent control conditions. Children were read two commercially available stories marketed for prekindergarten children matched in age-appropriate content, length, and readability. In Experiment 1, we investigated the effects of a contingent book on children's story recall and engagement compared to a noncontingent board book control. Second, we examined whether the contingent book might be especially useful for children with less developed attention regulation. In Experiment 2, we replicated Experiment 1 with a noncontingent digital book so children were presented with both stories on a digital platform to be certain that the effects found in Experiment 1 were not due to the novel effect of technology. In Experiment 3, we replicated Experiments 1 and 2 with a noncontingent animated book to ensure that the effects found in the first two experiments were not solely driven by the illumination and movement from animations. Participants' engagement in each presentation was assessed by coding eye gaze duration toward each book condition, and children were asked questions about each narrative to assess story recall. Independent assessments of attention regulation and verbal ability were also administered.

Based on previous work on contingent responsivity in adult-child interactions increasing children's learning and engagement, we hypothesized that the contingent book would increase children's story recall and looking duration toward the book during the reading session compared to the noncontingent books. Previous studies have found that contingent responsivity supports children's limited attention skills and facilitates learning by directing attention to relevant content (Kirkorian et al., 2016; Nussenbaum & Amso, 2016). Therefore, we hypothesized that the addition of story-related features that activate contingently on children's vocalizations would be especially beneficial for children who are easily distracted and score lower on the attention task. That is, because of these children's limited ability to focus on relevant material while suppressing extraneous details, they are the ones

who might benefit the most from the guidance of self-paced story features that match their vocalizations.

Experiment 1

Method

Participants. All participants were recruited from the same preprimary school on the campus of a private university in a Mid-Atlantic city in the United States. The school environment represents local racial and economic diversity with children being 74% White, 10% Asian or Pacific Islander, 7% Black or African American, 6% Middle Eastern, and 3% Hispanic, with only 15% from university-affiliated households and 33% of children attending on a partial or full scholarship. We based our target sample size on prior published work assessing the effect of e-books on child learning. The sample sizes in each experiment are comparable to prior studies that examined the effects of e-books on learning in preschool-aged children (Moody, Justice, & Cabell, 2010; Smeets & Bus, 2012; Strouse et al., 2013). Experiment 1 used a within-subject design with data from 35 children (16 male) ages 3 to 5 years old (M = 55.54 months, SD = 9.64 months). An additional child was tested but excluded due to equipment failure. The experimental protocol was approved by the Carnegie Mellon University Institutional Review Board (study title: Learning and Development from Infancy to Adulthood, IRBSTUDY2015_00000471). Signed consent was obtained from the parents of participants. Children were tested individually by hypothesis-blind research assistants and given stickers for participation.

Materials and procedure. Full descriptions of the materials, instructions, and procedure are provided in the online supplemental materials. The online supplemental materials serve to share details about the study protocol, materials, and additional analyses. Here we provide summaries of each.

Book conditions. To maintain a high level of ecological validity, children were read two commercially available stories marketed for emergent readers written and illustrated by the same author (Thacher Hurd), matched in artistic style, page length, and readability: *Cat's Pajamas* and *Zoom City*. Children were read one of the stories in the presentation of a noncontingent board book control condition and the other story in the presentation of the experimental contingent book condition. Condition and story order were counterbalanced. With permission from the author, both stories were converted into digital versions with the addition of contingent responsivity. The contingent responsivity was story-related animations that activated contingently on the child's vocalizations. When children said a word from the story aloud, the contingent book responded with story-related animations (e.g., child says "car" and a picture of a car animates by popping off the page). The contingent book was presented to children on an Apple iPad (9.4 in. × 6.6 in.). When a word from the story was vocalized by the child, a congruent picture that represented the word grew in size with a short (500 ms) animation and then shrank back to its original size. For example, when children vocalized the text from *Zoom City*, "fix the headlight," the animation of a wrench turning generated when the word "fix" was vocalized, and the animation of the car's headlight flashing on and off generated when the word "headlight" was vocalized (see Figure 1 for static image of book page). Animations represented the meaning of verbs and nouns in

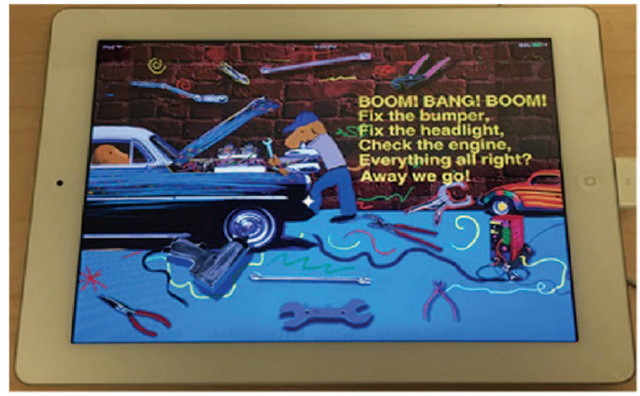

Figure 1. Adapted with permission from "Zoom City," by T. Hurd, 1998, pp. 7–8. Copyright 1998 by Thacher Hurd. See the online article for the color version of this figure.

the text (see Table S1 and Table S2 in the online supplemental materials for vocalized words that produced animations in each story).

The contingent book responded to only the child's vocalizations, not the reader's. To make this feature possible, the digital versions of *Cat's Pajamas* and *Zoom City* were converted into apps using Framer Software, a design tool engineered for interaction work. Framer Software permitted the iPad to partner with another device so that the visual display on the iPad was also mirrored on a MacBook Pro 15-in. laptop. When the reader-child dyad swiped to the next page on the iPad, this was also displayed on the laptop. As the reader in the reader-child dyad read the contingent book to the participant on the iPad, a trained experimenter in an operations control room activated the content-related animations contingently on the child's vocalizations using the laptop. If a child vocalized the word "car" from the story, the experimenter using the laptop activated the animation of the car. The testing room with the reader-child dyad was connected to the operations control room, but the rooms were separated with a curtain (see Figure S1 in the online supplemental materials for layout of how the experimenter activated animations contingently on the child's vocalizations). This setup made the pronounced vocalizations of the child, which signaled when to generate the animations, audible to the experimenter.

The reader in the reader-child dyads was a trained, hypothesis-blind research assistant who was instructed to read the books aloud to participants. For both book conditions, the reader was the same and started each session by reading the first line of the story; they then said, "Now it's your turn to read!" to the child and paused. This prompt was stated for the first page of each story, and children responded by repeating the first line segment. This prompt encouraged children to vocalize similar to how adult readers in dialogic shared reading interactions pause and encourage children to repeat the words in the story during the shared reading sessions (Strouse et al., 2013). For both conditions, the reader followed the protocol of pausing after each line in the story for 5 s until the child vocalized the words to model prior research paradigms finding a positive association between the duration of time adults pause for children to respond and the information children retain from the story (Read, Macauley, & Furay, 2014; see Table 1 for total pages,

Table 1
Pages, Lines, Animations, and Vocalizations by Story

Measure	*Zoom City*	*Cat's Pajamas*
Total pages	14	14
Total lines	29	31
Total animations	32	30
Mean vocalizations (*SD*)	96.74% (5.67%)	96.80% (6.16%)

lines, and animations by story). The reader continued reading each line in the book like traditional shared book reading, and if the child did not practice reading the line after 5 s, the reader moved on and read the next line. Because the amount of feedback is highly variable from adults during shared book reading and the quantity and quality of feedback influences children's learning outcomes, these instructions were implemented to ensure the effects of the contingent book and noncontingent control book could be examined with minimal influence from extratextual talk from the reader. On average, each story had approximately three words per line because short segments suited for beginning readers have been found to be optimal length in echo reading interactions (Jennings et al., 2013). In both reading conditions, the reader listened attentively to children's vocalizations, and as in traditional shared book reading, if children made any extratextual queries or comments, they were answered with the prompt "That's interesting, what do you think?" so that children's extratextual comments and queries were neither encouraged or discouraged (Sénéchal, 1997). Vocalizations were coded as the percentage of words the participant said aloud out of the total words in the story. Across all three experiments, there were no significant differences in vocalizations, and there was a ceiling effect: children were inclined to vocalize all the words in the stories after the reader across conditions. Therefore, vocalization data were not included in subsequent analyses (see Table 1 for mean vocalizations by story; see the online supplemental materials for vocalization coding and reader protocol).

Procedure. All sessions took place in the same testing room that permitted detailed audio and video recordings. Reader-child dyads were taped with two digital cameras: a Logitech C920 HD Pro Webcam and a Panasonic HDC-HS80 Camcorder. Each session was recorded using a Talent USB-1 Studio Condenser Microphone to obtain high-quality recordings of children's responses to the recall questions. Audacity 2.1.3 software was used to record and create an audio file (sample rate 44,100 Hz, sample format 16-bit, bit rate 96 kbps) of each session. Once produced, the audio file was exported to MP3 format for analysis. Engagement and responses to the recall questions were coded offline based on video and audio recordings of the testing sessions.

Measures.

Story recall measure. Story recall is considered one of the most appropriate assessments for children and is assessed through narrative reconstruction of retelling events that play a central role in the structure of stories (Kendeou, Van den Broek, White, & Lynch, 2009). Narrative reconstruction consists of children recalling the characters, settings, character goals, and solutions from the stories (Gibbons, Anderson, Smith, Field, & Fischer, 1986). At the end of each book condition, children were asked questions that probed their memory for details about the story that fit the narrative reconstruction criteria, which were pilot tested on 20 3- and 5-year-olds who were read both stories in the lab. Questions were adjusted so assessments were equally challenging between stories, with neither presenting floor or ceiling effects. The final assessment included 10 questions, scored out of a total of 14 points, for each story about the setting, plot, theme, and resolution and character descriptions, goals, and actions (see the online supplemental materials for recall assessments by story). There were seven 1-point questions, two 2-point questions, and one 3-point question. For example, in *Zoom City* the main character's actions were fixing the bumper, headlight, and engine on a car. For the 3-point question, children were asked to recall which parts on the car the character fixed. Children could receive full credit if in their response they identified the three car parts that were fixed, 2 points if they identified two parts, 1 point if they identified one part, and 0 points if they failed to recall the parts that were fixed or provided an incorrect response. Similar for scoring, in *Cat's Pajamas* the main character's actions were making music using drums, cans, and a horn. For the 3-point question, children were asked to recall which instruments the character played. Children could receive full credit if in their response they identified the three instruments that were played, 2 points if they identified two instruments, 1 point if they identified one instrument, and 0 points if they failed to recall the instruments that were played or provided an incorrect response. Story recall was measured as the percentage of correct responses (out of 14 possible points). Hypothesis- and condition-blind research assistants who received extensive training on using the audio recordings of each session listened to session recordings and coded story recall performance. Interrater reliability using Cohen's kappa (Cohen, 1960) was .86, indicating substantial coder consistency.

Engagement measure. Time on task (i.e., attending to the book while being read to) was measured via gaze fixation duration, which is a common measure of engagement in a variety of settings and is a particularly appropriate measure in the context of reading. Hypothesis-blind research assistants reviewed the video recordings of the testing sessions to calculate the child's fixation duration to each book condition from the direction of the participant's gaze. A "look" to the contingent book or control book was coded each time the child's gaze was directed at the book presentation. When the participant's gaze shifted (i.e., to the reader or off-task), a look to the new direction was coded. Each eye shift was judged as either toward or away from the book, and the duration of the resulting looks was analyzed to calculate total looking time. Total reading time was calculated as the time period from the moment the first word of the book (the title) was read aloud by the reader and continued until the book was finished. Engagement was measured as the percentage of time children spent looking at the book condition out of total reading time. For eye gaze durations toward each book condition, interrater reliability (Cohen's κ = .93) was established for at least 20% of the entire sample.

Attention measure. Between the reading sessions, children participated in a modified attention subtest from the Developmental Neuropsychological Assessments (NEPSY; Cuevas & Bell, 2014; Korkman, Kirk, & Kemp, 1998). The attention subtest is a visual cancellation task in which participants are asked to maintain selective attention and focus on targets with speed and accuracy. Children actively scanned a visual environment and pointed to only items that matched that target stimuli (i.e., bowling pins) on

a page containing both distractors and targets as quickly as possible in 180 s. Performance on the task was calculated using the total number of attention task errors and the total amount of search time to complete the task. Accuracy (distractor hits) and speed (search time) from the attention task were standardized using z scores and averaged together to create the composite variable: *distractibility*. This composite variable measured children's ability to complete the task accurately without getting distracted and fluently with speed.

Verbal ability measure. The Peabody Picture Vocabulary Test (PPVT-IV; Dunn & Dunn, 2007) was administered to children at subsequent laboratory visits within 3 weeks of the initial lab visit. A trained researcher presented a series of pictures to the child (four pictures per page) and verbally said a word that matched one of the pictures. Children were asked to point to the picture that the word described. The PPVT is a nationally standardized instrument, and the measure of interest was participants' age-based standardized scores.

Data analytic approach. To investigate our primary hypothesis—that contingent interactive features would improve story recall—we assessed how well children could answer questions related to the content of the story they had heard, administered after each story was finished. Story recall was measured as the percentage of correct responses out of 14 possible points (see Table 2 for raw and scaled scores). To assess possible order effects and sex differences, we conducted a mixed factorial analysis of variance (ANOVA) on story recall, factoring order, and sex as between-subjects variables and book condition as the within-subject variable.

Next, we investigated whether the use of the contingent book might be especially useful for children with less developed attention regulation. For this analysis, a recall difference score for each child was calculated by subtracting the noncontingent control book recall score from the contingent book recall score. Difference scores estimated changes in story recall performance from using the contingent book such that higher and positive scores indexed greater gains in story recall. To examine the association between changes in recall from the contingent condition and attention regulation, attention task distractors and time to complete the attention task were standardized using z scores and averaged together to create the composite variable: distractibility. Prior research has found that children's attentional control in preschool is related to later reading skills (Conners, 2009; Franceschini, Gori, Ruffino, Pedrolli, & Facoetti, 2012). To control for the potential role of verbal ability in the association between attention and recall difference scores, participants returned to the laboratory within 3 weeks of the initial lab visit and were administered the PPVT to ensure that findings would not be entirely due to variance shared with verbal ability (see Tables S3 and S4 in the online supplemental materials for correlation coefficients between measures of attention, recall, engagement, and verbal ability). To examine the extent to which distractibility uniquely predicted how much children's story recall changed from the contingent condition, a multiple regression analysis was conducted that included distractibility and verbal ability as predictors of children's recall difference scores and age in months as a covariate. Post hoc power analyses using G*Power (Faul, Erdfelder, Buchner, & Lang, 2009) indicated that the samples in each experiment were adequate for the mixed factorial ANOVAs (power = .94–.99) and multiple regression analyses (power = .95–.99) to detect the effect sizes observed.

Table 2
Recall and Engagement Measures by Condition

Measure	Noncontingent board book M (SD)	Contingent book M (SD)
Story recall raw scores	6.63 (2.44)	8.43 (2.59)
Story recall (% of 14)	47.35% (17.42%)	60.20% (18.52%)
Reading time (ms)	141,364 (37,795)	142,909 (34,787)
Looking time at book (ms)	137,303 (31,290)	141,182 (32,214)
Engagement (%)	97.89% (4.52%)	99.01% (2.87%)

Results

Story recall. There was a main effect of book condition; children's recall scores were significantly higher in the contingent book condition (M = 60.20%, SE = 3.13%) than the noncontingent board book condition (M = 47.36%, SE = 2.94%), $F(1, 30) = 39.57$, $p < .0005$, $\eta_p^2 = .57$. There was no main effect of order, $F(3, 30) = 1.04$, $p = .39$, or sex, $F(1, 30) = .12$, $p = .74$, and no significant interactions between any of these factors and story recall (all $p > .19$). The outcome for each condition of the recall measure followed a normal distribution, and there were no outliers. Follow-up pairwise comparisons after Bonferroni corrections revealed that on average, children scored 12.65% (SE = 2.01%) higher on the recall assessment in the contingent book condition compared to the noncontingent book condition, 95% CI [8.55%, 16.76%], $p < .0005$. All but six participants exhibited higher recall scores using the contingent book compared to using the noncontingent board book, two of whom exhibited identical scores across conditions. Taken together, these results indicate that children's mean story recall scores after being read to from the contingent book were higher compared to being read to from the noncontingent board book, regardless of the story or order in which the books were presented (see Figure 2 for paired box plot).

Engagement. The percentage of time children spent looking at the book condition out of total reading time did not significantly differ between the contingent book condition and the noncontingent board book condition. (see Table 2 for mean reading time and mean looking time toward book conditions). The results indicated a ceiling effect: children attended to the book throughout the entire reading session for both conditions. See the online supplemental materials for the analyses on the effect of book condition on engagement.

The role of individual differences in attention. Recall difference scores ranged from −14.29% to 42.86%, with a mean of 12.86% (SD = 12.23%). Standardized z scores of attention task distractors (M = 2.83, SD = 3.82) and time to complete the attention task (M = 125.40 s, SD = 55.61 s) were combined to create the composite variable of distractibility (M = −.22, SD = .71). Twenty-six participants returned to the laboratory and were administered the PPVT (M = 117.65, SD = 12.83). Higher distractibility scores, $r(35) = .57$, 95% CI [4.82, 14.79], $p < .0005$ (see Figure 3A), and lower verbal ability scores, $r(26) = -.42$, 95% CI [−.85, −.04], $p < .04$ (see Figure 3B), were associated

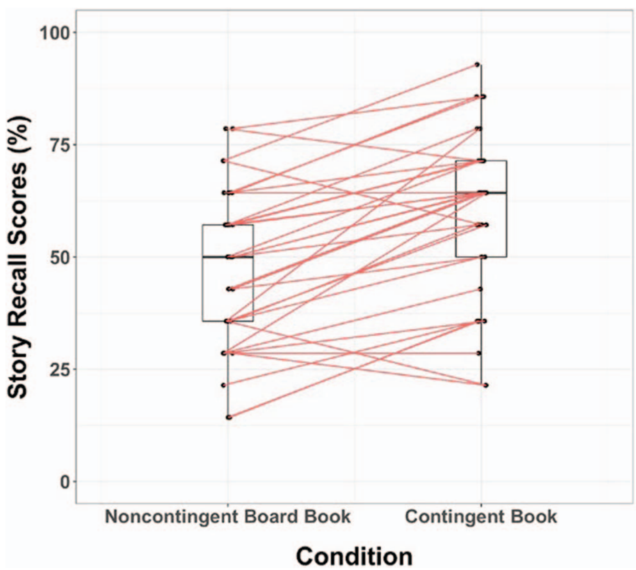

Figure 2. Paired box plot of recall scores in the noncontingent book and contingent book conditions. Data points were jittered in R by .02 to prevent overplotting (R Core Team, 2017). See the online article for the color version of this figure.

with how much children's recall changed from the contingent condition.

There was not a statistically significant interaction (F_{change} = 1.36, df = 6, 19, p = .29) between distractibility, age, and verbal ability and their effects on recall difference scores. Therefore, the final multiple regression analysis performed excluded the interaction terms as they were not significant. The additive model (F_{change} = 6.03, df = 3, 22, p = .004) revealed that distractibility accounted for unique variance in changes in recall using the contingent book (β = 9.76, t = 3.33, p = .003, 95% CI [3.67, 15.85]), but verbal ability and age did not (all $p > .21$; see Table 3). About 45.12% of the variability in recall difference scores is accounted for by taking the values of distractibility, verbal ability, and age into account. Thus, when accounting for other types of variables that may affect how much children's recall changes from the contingent book condition such as age and verbal ability, children's distractibility was the only unique predictor.

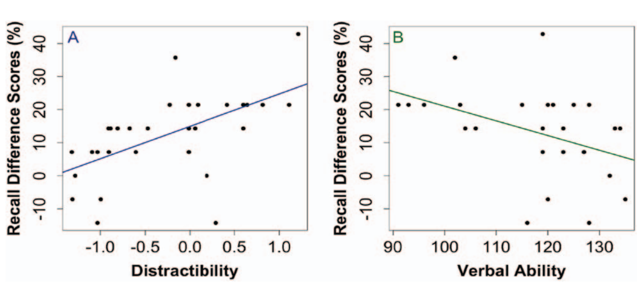

Figure 3. Scatterplots of correlations between recall difference scores and performance on the attention task and Peabody Picture Vocabulary Test (PPVT). Greater distractibility (A) and lower verbal ability (B) were associated with higher recall difference scores. There were no outliers. See the online article for the color version of this figure.

Table 3
Multiple Regression Analysis Predicting Changes in Recall From Contingent Condition

Statistic	β	*SE*	*t*	*p*	95% CI	*F*	*df*	R^2
Model				.004		6.02	3, 22	.45
Distractibility	9.76	2.94	3.33	.003	[3.67, 15.85]			
Verbal ability	−.23	.18	−1.28	.213	[−.61, .14]			
Age	1.04	2.97	−.35	.730	[−5.13, 7.21]			

Note. N = 26 for children who completed the Peabody Picture Vocabulary Test (PPVT).

Discussion

Results from Experiment 1 indicate that the use of the contingent book resulted in higher mean story recall compared to the use of the noncontingent board book. It was also found that children with less developed attention regulation exhibited the greatest gains in recall from the contingent book. However, it is an open question as to whether story recall was enhanced from the contingent book because of the contingent responsivity or because presenting a story on a digital platform is superior to a traditional board book, perhaps due to a novelty effect. A novelty effect occurs when a new technology is instituted, and performance improves simply because participants are exposed to a new device, not necessarily because participants are exposed to a more effective one (Clark, 1985). Experiment 2 begins to explore this possibility by replicating Experiment 1 with the control condition of a noncontingent static digital book, eliminating the possibility of the effects being driven by the novel effect of technology. Experiment 2 also attempts to replicate the results of investigating whether the contingent book might be especially useful for children with less developed attention regulation.

Experiment 2

The goal of this experiment was to assess the possibility that the results on children's story recall in Experiment 1 were solely because exposure to a book on a digital platform is superior to a board book, perhaps due to a novelty effect (that is, children may have been more attentive to the iPad than the board book simply because they were less familiar with iPads). To assess this possibility, in this experiment both a contingent and a noncontingent story are presented to children via an iPad. If the effects on recall observed in Experiment 1 are due to the contingent responsivity of the story (rather than the presence of an iPad), the story recall advantage for the contingent book should be reproduced in this experiment.

Method

Participants. All participants were recruited from the same preprimary school, and none of these children participated in Experiment 1. The study used a within-subject design with data from 33 children (20 male) ages 3 to 5 years old (M = 53.32 months, SD = 7.15 months). An additional child was tested but excluded due to speaking English as a second language with low proficiency; this child could not understand the stories or the recall questions.

Materials and procedure. Procedure and apparatus (recording equipment, reader protocol) were identical to those described in Experiment 1. The materials were nearly identical to those of Experiment 1. The one difference was that the noncontingent control condition was a static digital book presented on an Apple iPad (9.4 in. × 6.6 in.). The contingent and static books were identical in platforms, but the contingent book responded contingently on children's vocalizations while the static book remained motionless. As in Experiment 1, children were read *Cat's Pajamas* and *Zoom City*. Each story was read on an iPad, presented either with noncontingent static images or with animations that contingently responded to the child's utterance. Condition and story order were randomly assigned and counterbalanced. The measures of story recall, engagement, attention, and verbal ability were identical to the measures described in Experiment 1. The same data analytic approach as in Experiment 1 was used.

Results

Story recall. There was a main effect of book condition in that children's recall scores were significantly higher in the contingent book condition (M = 64.72%, SE = 2.47%) compared to the noncontingent static book condition (M = 45.89%, SE = 1.89%), $F(1, 28) = 42.34$, $p < .0005$, $\eta_p^2 = .60$ (see Table 4 for raw and scaled scores). There was no main effect of order, $F(3, 28) = .19$, $p = .91$, or sex, $F(1, 28) = 2.18$, $p = .15$. There were also no significant interactions between any of these factors and story recall (all $p > .37$). Follow-up pairwise comparisons after Bonferroni corrections revealed that on average, children scored 18.17% (SE = 2.79%) higher on the recall assessment in the contingent book condition compared to the noncontingent book condition, 95% CI [12.45%, 23.89%], $p < .0005$. All but five participants exhibited higher recall scores using the contingent book compared to using the noncontingent static book, all five of whom exhibited identical scores across conditions. The outcome for each condition of the recall measure followed a normal distribution, and there was one outlier with a recall score of 28.57% in the contingent book condition. With the removal of this outlier, there was still evidence of a main effect of book condition on recall, $F(1, 27) = 48.00$, $p < .0005$, $\eta_p^2 = .64$. Taken together, these results indicate that children's mean story recall scores after being read to from the contingent book were higher compared to being read to from the noncontingent static book, regardless of the story or order in which the books were presented (see Figure 4 for paired box plot).

Engagement. Consistent with Experiment 1, there was a ceiling effect: children attended to the book throughout the entire reading session for both conditions. The percentage of time children spent looking at the book condition out of total reading time did not significantly differ between the contingent book condition and the noncontingent static book condition (see Table 4 for mean reading time and mean looking time toward book conditions). See the online supplemental materials for the analyses on the effect of book condition on engagement.

Table 4
Recall and Engagement Measures by Condition

Measure	Noncontingent static book M (SD)	Contingent book M (SD)
Story recall raw scores	6.42 (1.52)	9.06 (1.98)
Story recall (% of 14)	45.89% (10.87%)	64.72% (14.17%)
Reading time (ms)	140,433 (35,567)	145,900 (34,098)
Looking time at book (ms)	136,567 (35,437)	143,167 (33,213)
Engagement (%)	97.10% (3.65%)	98.18% (2.13%)

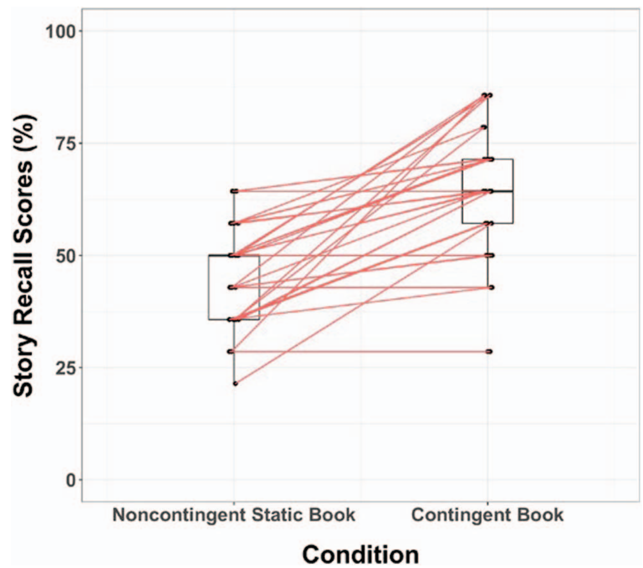

Figure 4. Paired box plot of recall scores in the noncontingent book and contingent book conditions. Data points were jittered in R by .02 to prevent overplotting (R Core Team, 2017). See the online article for the color version of this figure.

The role of individual differences in attention. With the goal of replicating results from Experiment 1, we examined whether the use of the contingent book might be especially useful for participants with less developed attention regulation. Recall difference scores ranged from 0.00% to 57.14%, with a mean of 18.83% (SD = 15.45%). Standardized z scores of attention task distractors (M = 5.94, SD = 6.09) and time to complete the attention task (M = 169.29 s, SD = 33.08 s) created the composite variable of distractibility (M = .50, SD = .75). Thirty-two participants returned to the laboratory and were administered the PPVT (M = 116.91, SD = 16.37). Higher distractibility scores, $r(33) = .71$, 95% CI [9.16, 19.76], $p < .0005$ (see Figure 5A), were associated with how much children's story recall changed from using the contingent book condition, but verbal ability scores were not, $r(32) = -.04$, 95% CI [−.32, .39], $p = .83$ (see Figure 5B). There were three outliers with PPVT scores of 85, 83, and 65. With the removal of these outliers, there was still not a significant association between verbal ability scores and children's recall difference scores, $r(29) = .23$, 95% CI [−.23, .94], $p = .23$.

There were no statistically significant interactions (F_{change} = .39, df = 6, 25, $p = .77$) between distractibility, age, and verbal ability and their effects on recall difference scores. Therefore, the final multiple regression analysis performed excluded the interaction terms as they were not significant. The additive model (F_{change} = 12.19, df = 3, 28, $p < .0005$) revealed that distractibility ($\beta = 17.57$, $t = 5.94$, $p < .0005$, 95% CI [11.51, 23.64])

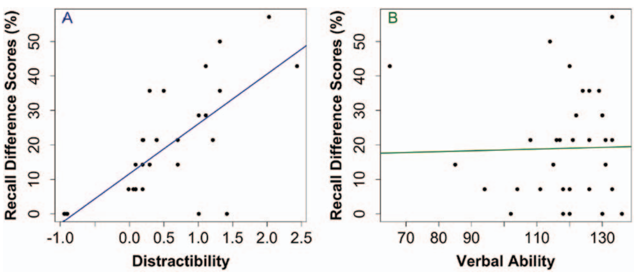

Figure 5. Scatterplots of correlations between recall difference scores and performance on the attention task and Peabody Picture Vocabulary Test (PPVT). Panel A: Greater distractibility was associated with higher recall difference scores. Panel B: Verbal ability was not statistically associated with recall difference scores. See the online article for the color version of this figure.

accounted for unique variance in changes in story recall using the contingent book, but verbal ability and age did not (all $p > .05$; see Table 5). About 56.64% of the variability in recall difference scores is accounted for by taking the values of distractibility, verbal ability, and age into account.

Discussion

Results from Experiment 1 revealed that children's recall scores were significantly higher in the contingent book condition compared to the noncontingent board book condition. These findings were replicated in Experiment 2 using a noncontingent electronic book condition, discarding the possibility that exposure to the contingent book was superior for children's story recall compared to the noncontingent board book due to the novel effect of being presented with an iPad. Findings from Experiment 2 also replicated the result from Experiment 1 that the contingent book was especially useful for children with less developed attention regulation.

Although verbal ability was not found to be a significant predictor of how much children's recall changed from the contingent book condition, this finding does not indicate that vocabulary ability is completely unrelated to story recall. The books utilized in this study contained vocabulary that was designed to be comprehensible to all children in this age range. A plausible reason that individual differences in vocabulary knowledge were not predictive of how much children's recall benefited from the contingent book is that children's verbal ability skills were above the vocabulary level of the books; therefore, the vocabulary gains would not be as evident as the recall gains.

Children use salience cues like illumination and movement when learning content, and children's selective attention to salient features congruent with content predicts better learning (Moore, Angelopoulos, & Bennett, 1999). It is plausible that animations congruent to the text enhanced children's story recall by orienting their attention to nonverbal information that matched the story narrative. Experiment 3 begins to explore this possibility by replicating Experiments 1 and 2 with the control condition of an animated book presentation in which congruent animations are deployed, but they do not respond contingently on the vocalizations of the child.

Experiment 3

The goal of this experiment was to assess the possibility that the results on children's story recall in Experiments 1 and 2 were solely because exposure to animations is superior to motionless images, perhaps due to salience cues. To do so, in this experiment participants were presented with both a contingent book condition and a noncontingent animated book control. In the animated book condition, the story-related animations are deployed for each page, but they do not respond contingently to the vocalizations of the child. If the effects observed in Experiments 1 and 2 are due to the contingent responsivity of the story (rather than the mere presence of animations), the recall advantage for the contingent condition should be reproduced in this experiment.

Method

Participants. All participants were recruited from the same preprimary school as in Experiments 1 and 2, and none of these children participated in either Experiment 1 or Experiment 2. The study used a within-subject design with data from 22 children (11 male) ages 3 to 5 years old (M = 54.29 months, SD = 7.33 months). Four additional children were tested but excluded due to equipment failure. The sample size is smaller than the sample sizes in Experiments 1 and 2 because there were no children left in the preprimary school to test and recruiting participants from different schools might introduce potential confounds.

Materials and procedure. Procedure and apparatus were identical to those described in Experiments 1 and 2. The materials were nearly identical to the two previous experiments. The one difference was that the noncontingent control condition was an animated book. As in Experiments 1 and 2, children were read *Cat's Pajamas* (Hurd, 2015) and *Zoom City* (Hurd, 1998). Children were read each story in the presentation of a noncontingent animated book or in the presentation of a contingent book. Condition and story order were randomly assigned and counterbal-

Table 5
Multiple Regression Analysis Predicting Changes in Recall From Contingent Condition

Statistic	β	*SE*	*t*	*p*	95% CI	*F*	*df*	R^2
Model				<.0005		12.19	3, 28	.566
Distractibility	17.57	2.96	5.94	<.0005	[11.51, 23.64]			
Verbal ability	.10	.12	.83	.41	[−.15, .35]			
Age	6.68	3.36	2.05	.05	[−.01, 13.37]			

Note. N = 32 for children who completed the Peabody Picture Vocabulary Test (PPVT).

anced. The contingent and animated books were identical in pictures, text, platforms (Apple iPad 9.4 in. × 6.6 in.) and animations; however, while the contingent book's animations deployed contingently on children's vocalizations, the animated book's animations were deployed at the start of each page. Identical to Experiments 1 and 2, for the contingent book, the reader started each session by reading the first line of the story and then said, "Now it's your turn to read!" to the child. For the animated book, the animations were deployed, the reader read the first line of the story, and the reader then said, "Now it's your turn to read!" to the child (see the online supplemental materials for reader protocol).

We explored the control conditions of having the animations deploy at the end of each page's narration and in response to the adult's vocalizations rather than the child's, but pragmatic considerations and pilot testing favored page-initial animations. Deploying the animations contingently on the adult reader's vocalizations and having the animations occur after the page was read were control conditions too similar to the contingent book condition because several of the animations appeared to respond contingently on children's vocalizations by chance. By having the animations deploy at the start of each page, it was possible to have a control book condition in which the relevant story information was highlighted without the animations appearing to respond contingently on children's vocalizations.

Measures. Measures of story recall and attention were identical to the measures described in Experiment 1 and Experiment 2. Due to the time-intensive and laborious nature of coding children's eye gaze fixations and recruiting children to return to the laboratory for an additional testing session, the engagement and vocabulary measures were not included in Experiment 3 because there were no effects of book condition on engagement. The multiple regression analyses also revealed that PPVT performance lacked predictive power in Experiments 1 and 2.

Results

The same data analytic approach as in Experiment 1 and Experiment 2 was used with one distinction. The one difference was that the multiple regression analysis conducted did not include verbal ability as a predictor of recall difference scores. Only attentional control and age were included in the multiple regression analysis as predictors of how much children's story recall benefited from the contingent book.

Story recall. There was a main effect of book condition in that children's recall scores were significantly higher in the contingent book condition (M = 59.42%, SE = 3.06%) compared to the noncontingent animated book condition (M = 45.13%, SE = 2.46%), $F(1, 17) = 39.97$, $p < .0005$, $\eta_p^2 = .70$. There was no main effect of order, $F(3, 17) = 3.05$, $p = .06$, or sex, $F(1, 17) = .23$, $p = .64$. There were also no significant interactions between any of these factors and story recall (all $p > .22$). Follow-up pairwise comparisons after Bonferroni corrections revealed that on average, children scored 14.33% (SE = 2.27%) higher on the recall assessment in the contingent book condition compared to the noncontingent book condition, 95% CI [9.55%, 19.11%], $p < .0005$. All but three participants exhibited higher recall scores using the contingent book compared to using the noncontingent animated book, two of whom exhibited identical scores across conditions. The outcome for each condition of the recall measure followed a normal distribution, and there was one outlier with a recall score of 100.00% in the contingent book condition. With the removal of this outlier, there was still evidence of a main effect of book condition on children's story recall, $F(1, 16) = 35.90$, $p < .0005$, $\eta_p^2 = .69$. Taken together, these results indicate that children's mean story recall scores using the contingent book were higher compared to the noncontingent animated book, regardless of the story or order in which the books were presented (see Figure 6 for paired box plot).

The role of individual differences in attention. Recall difference scores ranged from −7.14% to 35.71%, with a mean of 14.29% (SD = 10.80%). Standardized z scores of attention task distractors (M = 2.36, SD = 3.26) and time to complete the attention task (M = 108.66 s, SD = 62.94 s) created the composite variable of distractibility (M = −.41, SD = .79). The multiple regression analysis showed no significant interactions (F_{change} = 0.00003, df = 3, 18, p = 1.0) between distractibility and age and their effects on recall difference scores ($\beta = -.02$, $t = -.01$, p = 1.0). Therefore, the final multiple regression analysis performed excluded the interaction term as it was not significant. The additive model (F_{change} = 8.46, df = 2, 19, R^2 = .47, p = .002) revealed that distractibility (β = 9.02, t = 3.95, p = .0009, 95% CI [4.24, 13.81]) accounted for unique variance in changes in recall using the contingent book, but age did not ($\beta = -2.86$, $t = -.97$, p = .35, 95% CI [−9.04, 3.32]). There were no outliers. About 47.10% of the variability in recall difference scores is accounted for by taking the values of distractibility and age into account. The contingent book was especially helpful for children with less developed attentional control: as children's measure of distractibility increased, they showed more benefit in recall from using the contingent book (see Figure 7).

A possible explanation for the fact that age was never a significant predictor of how much children's story recall gained from the

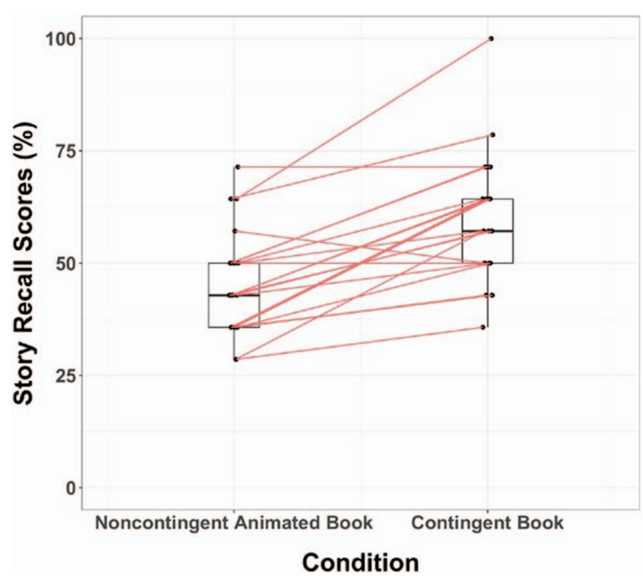

Figure 6. Paired box plot of recall scores in the noncontingent book and contingent book conditions. Data points were jittered by .02 in R to prevent overplotting (R Core Team, 2018). See the online article for the color version of this figure.

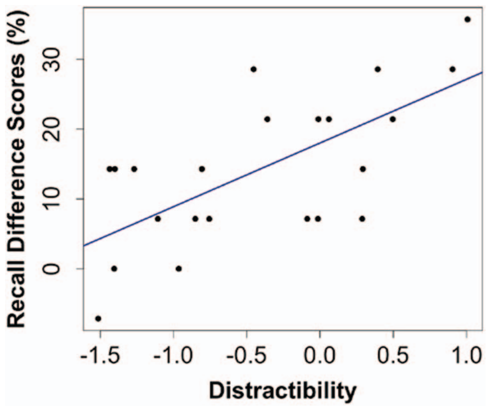

Figure 7. Scatterplot of correlation between recall difference scores and performance on the attention task. Greater distractibility was associated with higher recall difference scores. See the online article for the color version of this figure.

contingent book condition is that age is correlated with distractibility, so age in and of itself is not a strong predictor (see Figure S2 in the online supplemental materials for scatterplot of correlation between age in months and attention regulation across all three experiments). Animations that respond contingently may improve story recall beyond animations alone because even when animations direct attention to relevant story information, the salient cues are not effective unless they are in sync with the child. Contingent responsivity in adult-child interactions enhances learning because following a child's vocalizations with relevant responses adapts to the child's current focus of attention and encourages children to continue engaging throughout the reading experience, whereas animations that come beforehand do not give children immediate and appropriate feedback that match the child's communicative attempts and would foster understanding of the story content.

General Discussion

To our knowledge, these data provide the first systematic analysis of whether contingent responsivity on children's utterances from a digital book could support children's learning. There were significant differences in story recall, with nearly all children exhibiting higher recall scores from the contingent book compared to a noncontingent board book. Our findings were strengthened when these results were replicated in a second experiment comparing the use of the contingent book with a noncontingent static book, discarding the possibility that exposure to the contingent book was superior to the board book due to the novel effect of a digital device. Furthermore, it was shown that the animations were not driving the effect in a follow-up control experiment comparing the use of the contingent book with a noncontingent animated book. Similar to the effects contingent responsivity from adults has on children during shared book reading, when each of the children's vocalizations was returned with reinforced guidance to appropriate story content, this enabled children to later reproduce a better understanding about the story. One limitation is we were unable to conduct accurate a priori power analyses because of the novel technical aspects of the study methodology. Although conservative interpretations should be drawn from post hoc power analyses and the small sample size of each experiment, the present findings extend the literature in several ways. First, this is one of the first within-subject studies that investigated the effects of contingent responsivity from a digital book on story recall with a focus on individual differences in attention regulation. Second, the present study highlighted the specific nature of the contingent responses that is helpful for learning: children receiving a contingent response upon repeating the text. Third, the findings expand our knowledge of how preschool-aged children learn from contingent responsivity instilled in an e-book compared to how preschool children learn from other book contexts.

We hypothesized that children who attend to more distractors and take longer to complete the attention task (i.e., children with less developed attention regulation skills) would exhibit greater recall gains from the contingent book. Our findings support this hypothesis: the contingent responsivity was especially useful for children with the highest distractibility scores. Results also showed that the associations between distractibility and changes in recall from the contingent book were largely not due to variance shared with verbal ability. Children's attention regulation is a significant predictor of academic achievement not only when they enter formal schooling but also continue to predict academic success until several years later in development (Franceschini et al., 2012). While prior research has found that interactive features are distracting and detract from learning, caregiver behavior characterized by appropriately high levels of responsiveness has been found to buffer poor attention regulation in children (Graziano, Calkins, & Keane, 2011). The interesting finding in the differential impact of attention regulation for the contingent book advances current theories of the beneficial effects from contingent responsivity on young children's learning from *a digital device*. The novelty of these findings is that this study investigated individual differences in attention regulation in predicting story recall in the context of the interaction with various designs of e-books, a topic that is understudied. Although this study clearly exhibits a contingent responsivity advantage on story recall for children with less developed attention regulation, it does not address specific hypotheses regarding this advantage. Two plausible overlapping hypotheses that support this advantage are the roles of positive reinforcement learning and associative learning with attention regulation.

Contingent use of positive reinforcement reduces attention regulation problems (Lunkenheimer et al., 2008). The comprehension of word-referent relations increases when adults provide actions considered to be positive to children (i.e., attention, praise, following their lead) contingent upon characteristics of the child's vocalizations (Whitehurst & Valdez-Menchaca, 1988). The contingent responsivity advantage in e-books on story recall for children with less developed attention regulation could potentially be elicited engagement through positive reinforcement: children's responses are required for progress through the story, e-books uniquely respond to children's responses, and acknowledgment and rewards through a contingent response from the book occur when children answer correctly (Troseth et al., 2016). Contingent responsivity also encourages children to be active rather than passive participants, and children's learning is optimized when they are engaged rather than distracted (Dore et al., 2018). Following a child's vocalizations with relevant responses adapts to the child's current focus of attention and encourages children to con-

tinue engaging throughout the reading experience, whereas typical e-books and interacting with books alone do not give children immediate and appropriate feedback that match the child's communicative attempts that would foster understanding of the story content. The contingent responses upon repeating the story text may provide children with feelings of accomplishment and may serve as positive reinforcement, which in turn enhance learning (Troseth et al., 2016).

Children scored lower on the attention task because these children's ability to selectively attend to relevant information while suppressing irrelevant, extraneous information is less efficient. Many storybook designs for young children integrate colorful visuals and decorative illustrations. Although the inclusion of entertaining visuals in children's reading materials has enormous potential to engage children—if children are not given the appropriate guidance to the content related to the story text—these additional visuals might be counterproductive if they distract children from processing the narrative (e.g., exploring pictures of cats when they should be focusing on pictures of cars). Children verbalizing a word with contingent feedback to the matching referent guides children's attention to story-relevant features that may improve encoding, storage, and retention of material and thereby facilitate subsequent retrieval and use (Schunk, 1986). The contingent animations that are synced with children's vocalizations signify to children the relevant material related to the story they should attend to and help them develop a better understanding of the story because the animations in the contingent book match the simultaneously pronounced story text. Children may encode the vocalized words and associated animations to form a unitary representation of the story content (Baker, Olson, & Behrmann, 2004). The actions of the contingent book and the children are coordinated and in sync with one another: the children vocalize, and the contingent book responds with referents that match those vocalizations. Because the animations in the contingent book match the simultaneously pronounced story text, the children are not forced to constantly switch between exploring the entertaining visuals in the storybooks and processing the story narrative. Instead, the visuals helped integrate nonverbal information and language. This contingent responsivity may be especially useful for children with less developed attention regulation because it encourages children to focus on relevant story content that matches their words, leading to better attention to the main story elements and therefore higher levels of story recall.

Children performed better in the contingent book condition across all ages in our experiments. The developmental trajectory for the effectiveness of contingent responsivity in digital books might change with a variety of age ranges. For younger children ages 1 to 2 years old who are developing their language production skills, the effects of contingent responsivity on story recall might not be as effective because developmentally, this age group is still learning to produce vocalizations. Attention regulation skills display protracted development and are still developing during the time when children begin formal schooling (Fisher & Kloos, 2016). Contingent responsivity in e-books may continue to be helpful for beginning readers ages 6 to 8 years old, who are in the process of learning how to read. A recent detailed analysis of 100 of the most popular books for beginning readers indicated that books targeting this age group commonly contain design features that increase attentional competition for young children: on average, 86.56% of a book's pages contained extraneous illustrations irrelevant to the story narrative, and attention allocation toward extraneous details was found to be negatively associated with children's ability to recall key story details (Godwin, Eng, Murray, & Fisher, 2019). Therefore, contingent responsivity in e-books may be helpful for beginning readers ages 6 to 8 years old, who are also commonly exposed to extensively embellished storybooks and whose attention regulation skills are still developing. The contingent responsivity may become less useful for older children ages 9 to 11 years old, who are starting to transition to chapter books without illustrations and whose attention regulation and reading skills are more developed.

A limitation to this study is that the recall assessment primarily focused on questions that require children to recall story information through identification and description. Although the main outcome measure in this study mainly focused on the recall of key story events, recent research has found that early childhood teachers use recall questions as the primary instructional strategy for comprehension in school settings and tend to ask lower-order literal questions that elicit one word responses from children (Walsh & Hodge, 2018), increasing the generalizability of these findings. Story recall competency is not only associated with global reading skills but is also a strong predictor of later reading comprehension and indicates a complex mix of children's understanding of stories and mastery of pragmatics, syntax, and semantics (Suggate, Schaughency, McAnally, & Reese, 2018). Furthermore, the most significant difference between children with reading disabilities and children with typical reading skills has been found to be performance on story retelling, showing that the recall of story elements is a useful context for identifying strengths and weaknesses in children's competency in understanding story narratives (Westerveld & Gillon, 2010). While the current study cannot make direct conclusions on the effect of contingent responsivity from an e-book on children's global story comprehension skills, the contingent responsivity did improve children's ability to recall key story details, a predictor of overall comprehension.

Future studies conducted with children from low socioeconomic (SES) households, second language learners, and children with attention deficits may validate our findings and give us a more thorough understanding of the effects of the contingent book for a diverse range of children. Due to decreasing costs, marketing strategies, and subsidies by providers, mobile media such as smartphones, iPads, and tablets are more accessible—even for low SES children. In 2011, 73% of higher income families owned a mobile device compared to the 34% of lower income families; in 2017, the percentages rose to 99% for higher income families and 96% for lower income families (Rideout, 2017). While the digital divide is closing, the amount of mobile media use and parental coengagement with media still differs between low SES and high SES households. Children from lower SES households spend almost twice as much time in front of a screen compared to children from higher SES households, and this exposure is also more likely to be unsupervised by a parent (Radesky & Christakis, 2016; Rideout, 2017). Children's use of the target words interacting with the book alone or without appropriate adult guidance may not be as consistent unless the book interacts in the manner adults were instructed to in the current study; but given that children may interact with digital devices alone, contingent responsivity functionality in e-books may be practical for times in which adults are unavailable

and when children are reading alone and might even be more beneficial than hardcopy, static, and animated books, as evidenced by the results from this study. Because experimenters were trained to do the bare minimum of simply reading the text aloud to children with minimal interaction and the contingent book led to increased story recall, we hypothesize similar results would be reproduced if prompts and narration were coming from the contingent book while children interact with the book alone or without the presence of an adult.

Media use by preschool children may not be by itself the critical concern; however, poorly designed educational devices might be. If a caregiver were reading a book to a child, it would seem almost obvious that stopping the child in the middle of the page to play a game or make an irrelevant noise would interrupt the flow of the story and distract the child from understanding the narrative. Yet this structure is how many interactive digital books are designed: with tactile puzzles, memory tasks, or entertaining sound effects and animations activated spontaneously on the story pages in ways that are not central to the narrative (Vaala, Ly, & Levine, 2015). When well-deployed and well-designed, features in technology have the potential to enrich, not hinder, learning experiences for children.

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